Tanta University

Faculty of Engineering

MECHANICAL DESIGN of OVERHEAD TRANSMISSION LINES (OHTL)

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SAG AND TENSION CALCULATIONS

Sag of Transmission Lines

- The sag of the conductor (vertical distance between the highest and lowest point of the curve) varies depending on the temperature and additional load such as ice cover.

Sag of T.L depends on:

- **Conductor weight.**
- **Span length,**
- **Tension in the conductor, T**
- **Weather conditions (wind , ice).**
- **Temperature.**

Sag and Tension in Overhead Transmission Line

While erecting an overhead line, it is very important that conductors are under safe tension.

If the conductors are too much stretched between supports in a bid to save conductor material, the stress in the conductor may reach unsafe value and in certain cases the conductor may break due to excessive tension.

In order to permit safe tension in the conductors, they are not fully stretched but are allowed to have a dip or sag.

Calculation of Sag

In an overhead line, the sag should be so adjusted that tension in the conductors is within safe limits. The tension is governed by conductor weight, effects of wind, ice loading and temperature variations. It is a standard practice to keep conductor tension less than 50% of its ultimate tensile strength i.e., minimum factor of safety in respect of conductor tension should be 2.

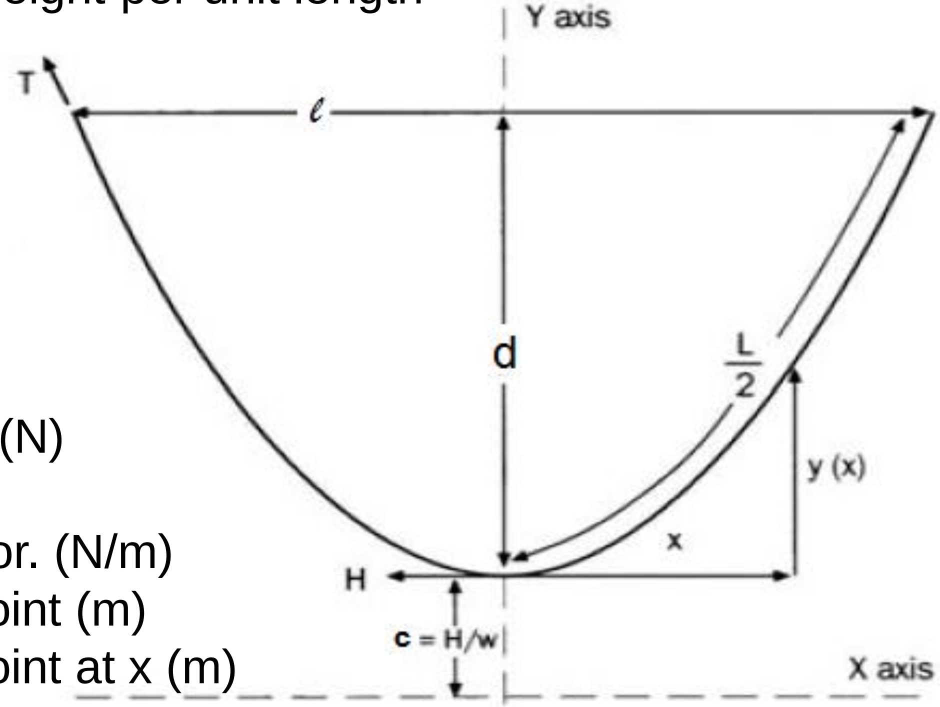
We shall now calculate sag and tension of a conductor when

(i) supports are at equal levels and

(ii) supports are at unequal levels.

(i) When supports are at equal levels

The shape of a hanging line attached in its two ends can be described as a function of horizontal tension and weight per unit length



where
S = Sag (m)
L = Span length (m)
H = Horizontal component of tension (N)
T = Total tension (N)
w = weight per unit length of conductor. (N/m)
x = horizontal distance from lowest point (m)
y(x) = vertical distance from lowest point at x (m)

Fig. Illustrates the meaning of sag, span length and line length,

The following points may be noted:

(i) When the conductor is suspended between two supports at the same level, it takes the shape of catenary.

However, if the sag is very small compared with the span, then sag-span curve is like a parabola.

(ii) The tension at any point on the conductor acts tangentially. Thus tension H at the lowest Point O acts horizontally as shown in Fig. (ii).

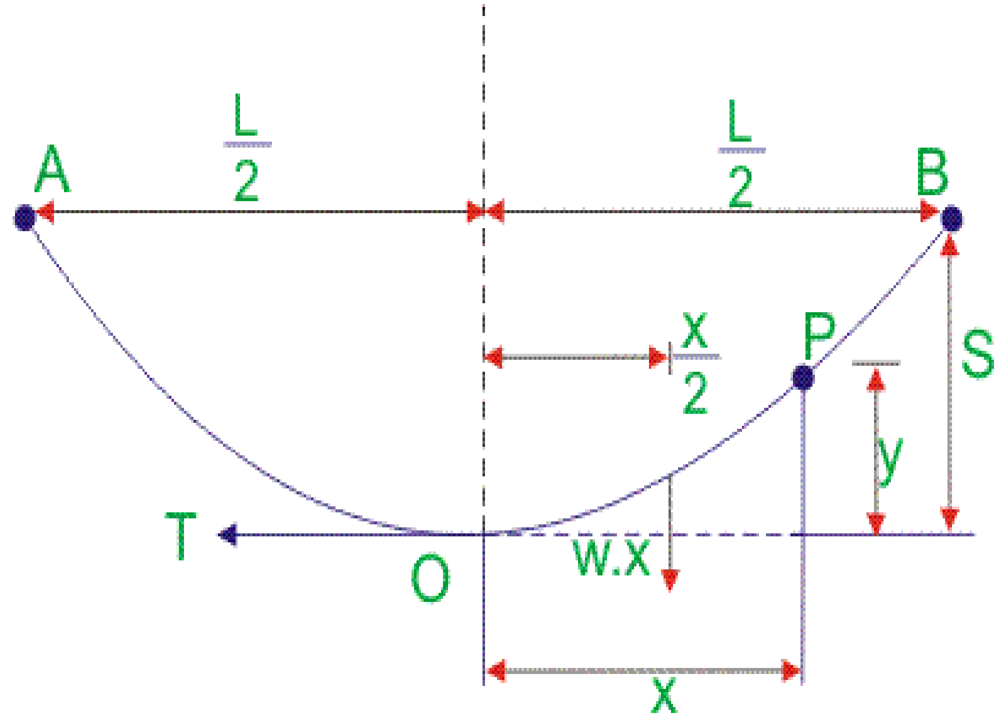
(iii) The horizontal component of tension is constant throughout the length of the wire.

(iv) The tension at supports is approximately equal to the horizontal tension acting at any point on the wire. Thus if T is the tension at the support B, then T = H.

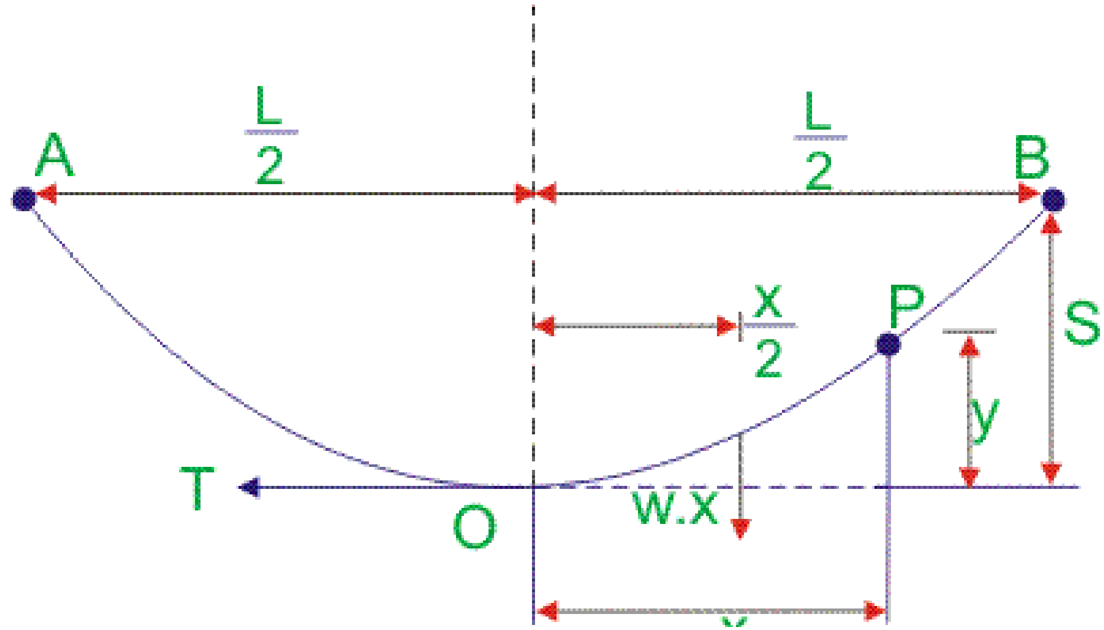
The shape of the hanging line can be described with an approximate parabolic equation or with a more exact hyperbolic catenary equation.

The error due to parabolic approximation is very small except for very long, steep or deep spans.

The parabolic equation, has the advantages that it easily shows the relationships between sag, tension, weight and span length.



Consider a point P on the conductor. Taking the lowest point O as the origin, let the co-ordinates of point P be x and y. Assuming that the curvature is so small that curved length is equal to its horizontal projection (i.e., OP = x), the two forces acting on the portion OP of the conductor are :



(a) The weight wx of conductor acting at a distance x/2 from O.

(b) The tension T acting at O.

Equating the moments of above two forces about point O, we get,

$$Ty = wx \times \frac{x}{2}$$

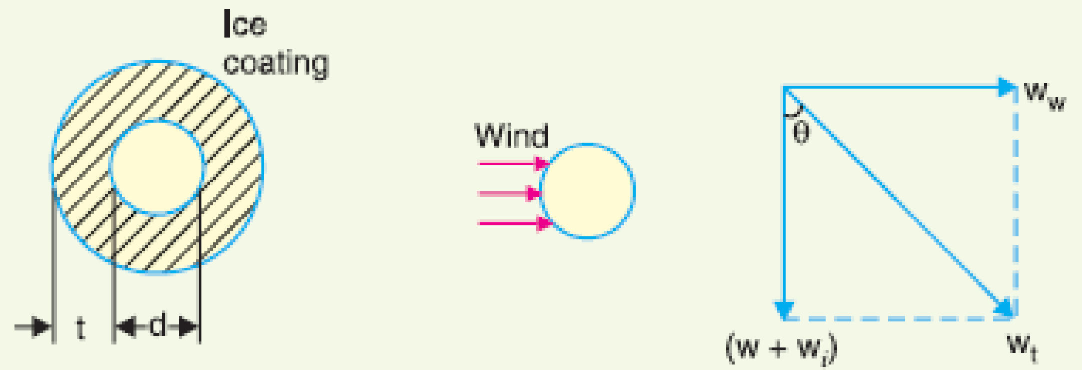
$$y = \frac{wx^2}{2T}$$

The maximum dip (sag) is represented by the value of y at either of the supports A & B.

At supports A $\qquad x = \frac{l}{2} \qquad$ and $y = s$

$$\text{Sag S} = \frac{\text{wl}^2}{8\text{T}}$$

Effect of ice and wind loading



(i) (ii) (iii)

Fig. 8.26

Total weight of conductor per unit length is

$$w_t = \sqrt{(w + w_i)^2 + (w_w)^2}$$

where

$$\begin{aligned}
w &= \text{weight of conductor per unit length} \\
&= \text{conductor material density} \times \text{volume per unit length} \\
w_i &= \text{weight of ice per unit length} \\
&= \text{density of ice} \times \text{volume of ice per unit length} \\
&= \text{density of ice} \times \frac{\pi}{4}[(d + 2t)^2 - d^2] \times 1 \\
&= \text{density of ice} \times \pi\, t\, (d + t)^* \\
w_w &= \text{wind force per unit length} \\
&= \text{wind pressure per unit area} \times \text{projected area per unit length} \\
&= \text{wind pressure} \times [(d + 2t) \times 1]
\end{aligned}$$

Effect of ice and wind loading

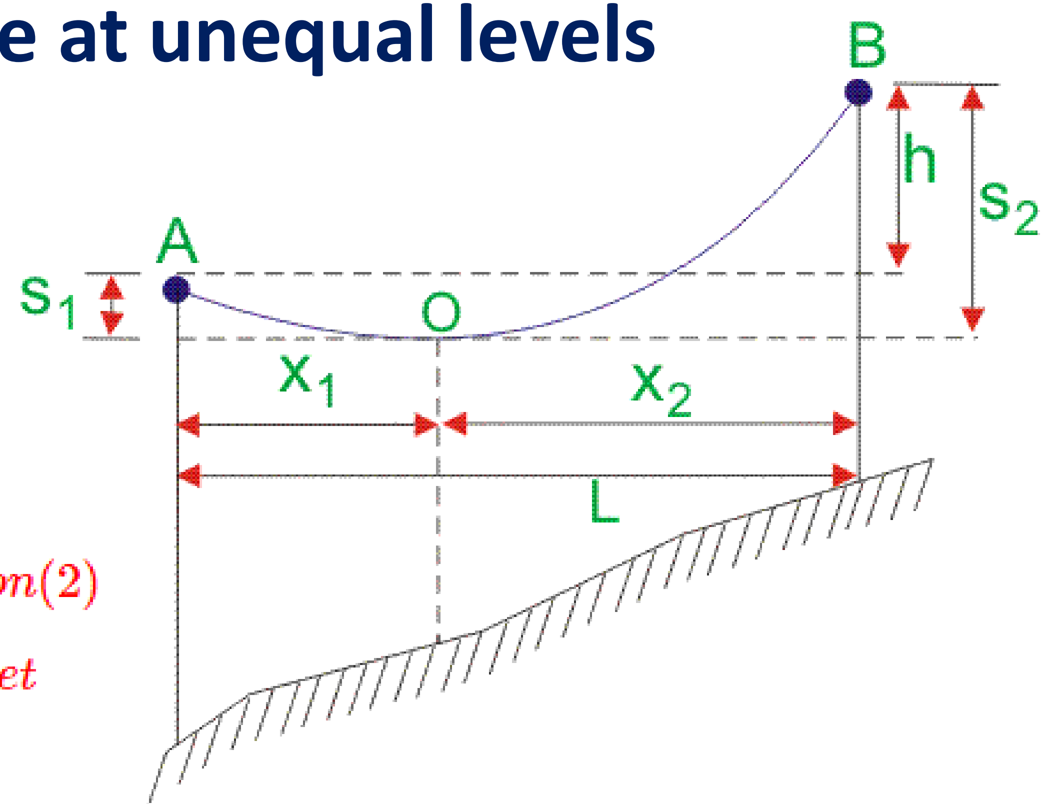
The sag in the conductor is give bv

$$S = \frac{w_t L^2}{2T}$$

So the vertical sag

$$S_v = S \cos\theta$$

(ii) When supports are at unequal levels



$$So, h = \frac{wL}{2T}(x_2 - x_1)$$

$$Or,\ (x_2 - x_1) = \frac{2Th}{wL} \ldots\ldots\ldots equation(2)$$

Solving equation (1) and (2), we get

$$x_1 = \frac{L}{2} - \frac{Th}{wL}\ and\ x_2 = \frac{L}{2} + \frac{Th}{wL}$$

$$Sag\ S_1 = \frac{wx_1^2}{2T}\ And\ Sag\ S_2 = \frac{wx_2^2}{2T}$$

$$Also,\ x_1 + x_2 = L \ldots\ldots\ldots equation(1)$$

$$Now,\ S_2 - S_1 = \frac{w}{2T}(x_2^2 - x_1^2) = \frac{w}{2T}(x_2 - x_1)(x_2 + x_1)$$

$$So,\ S_2 - S_1 = \frac{wL}{2T}(x_2 - x_1)$$

$$Again, S_2 - S_1 = h$$